

Mushrooms-Its production, nutritional and therapeutic profile, storage conditions and value addition

Beena Cherian¹, Shilpa Jose^{2*}

¹ Mar Athanasios College for Advanced studies, Thiruvalla, Pathanamthitta, Kerala, India

² Assistant Professor, St. Teresa's College, Ernakulam, Kerala, India

Abstract

Mushroom cultivation has great scope in India and in other developing countries because of the economical and easy availability of raw materials. The production of mushroom in India has enormously increased and attained the status of commercial crop. During the last two decades, cultivation of mushrooms has become popular worldwide because of the wide choice of species for cultivation under different agro climatic conditions and the ease of cultivation on different types of lignocellulosic materials. Considering these factors mushroom was emphasized in this review to depict the worldwide production and cultivation, nutritive value, therapeutic profile and the postharvest changes incurred in mushrooms. Though fresh mushrooms have limited shelf life after harvesting, various methods for appropriate packaging and storage conditions to enhance the shelf life and for processing into acceptable products can salvage the perishability of mushroom.

Keywords: mushroom, nutritive value, shelf life

1. Introduction

The developing country like India, is rich in varied agro climatic conditions, abundance of the agricultural wastes and manpower, making it most suitable for the cultivation of all types of temperate, subtropical and tropical mushrooms. Mushrooms are fungus of saprophytic species having a fleshy spore bearing fruiting body growing above the ground and a hyphae growing inside the dead organic matter of vegetable origin. Dung *et al* 2012^[29], stated that mushroom cultivation is a profitable agribusiness in world wide. At present, production of mushrooms has crossed lakh tons with annual growth rate of above 15 % (Sharma and Dhar, 2010)^[28]. Total commercial mushroom production in worldwide has increased more than 21 times in 35 years, from about 350,000 tons in 1965 to about 7.5 million tons in 2000 (Boa, 2004)^[31]. The world production of mushroom comprises nearly 5 million tons of fresh weight annually (Omarini *et al.* 2010)^[78]. According to Rosli *et al.* 2011^[93], global commercial mushroom production has skyrocketed by 35.9 percentage. *Lentinus edodes* and four other genera (*Pleurotus*, *Auricularia*, *Agaricus* and *Flammulina*) account for 85 % of the world's total supply of cultivated edible mushrooms. China, the leading producer of cultivated edible mushrooms (Royse *et al.* 2017)^[94]. Though mushroom production in Asian countries started 1000 years ago, cultivation of mushrooms is relatively new phenomenon in India. Mushrooms such as *Auricularia*, *Flammulina* and *Lentinula* were most likely cultivated for the first time around the year 600-800 AD in China and other Asian countries (Chang and Wasser, 2017)^[22].

In India, the total production of mushroom is about 1, 13, 315 tones (Wakchaure, 2011)^[117]. Production and consumption of edible mushrooms has tremendously increased throughout the world due to their nutritional and health benefits. The consumption of this fancied items is a natural corollary to the general booming in the economic development of a country. The report published by United

Nations in 2000 reveals that mushrooms are gaining popularity in the world as one of the most important vegetables of the twentieth century due to innumerable reasons like delicacy, appreciated for its good taste and nutrition and enticing flavor.

Production and cultivation of mushrooms

Mushrooms are being cultivated in more than 100 countries of the world with an estimated total production of over 12 million tons (Kamal *et al.* 2009)^[48]. Mushroom production is an ecofriendly activity where agricultural or industrial wastes are utilized and recycled. During the last four decades, mushrooms have attained the status of commercial crop (Ramkumar *et al.* 2011)^[88].

At present, production of mushrooms has crossed lakh in ton with annual growth rate of above 15% (Sharma and Dhar, 2010)^[28]. Lindequist *et al.* 2005^[62], reported that more than 2000 species of mushrooms exist in nature; however less than 25 species are widely accepted as food and only a few have attained commercial importance.

Oyster mushroom (*Pleurotus ostreatus*) stands third position produced by China with a production of 4,929,000 tonnes (FAO Stat, 2011). Presently Shiitake, oyster, wood ear and button mushroom contribute 22, 19, 18 and 15 percent respectively in terms of total mushroom production in the world (Singh *et al.* 2017)^[106]. Though 20 genera of mushrooms are being cultivated throughout the world, only four types viz Button mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus* species), Milky mushroom (*Calocybe indica*) and Paddy straw mushroom (*Volvariella volvacea*) are grown commercially in India (Rai *et al.* 2003). According to Sharma *et al.* 2017, out of the total mushroom produced, white button mushroom share is 73% followed by oyster mushroom (16 %), paddy straw mushroom (7%) and milky mushroom (3%).

In India, white button mushroom still contributes more than 85% of the total production, though its share is below 40%

in the global trade. India contributes about 3% of the total world button mushroom production (Prakasam, 2012) [83]. According to Sharma *et al.* 2017, Punjab, Uttrakhand, Haryana, Uttarpradesh and Tamil Nadu were the leading producer of the mushroom in the country at the time of 2010, whereas the present production status in 2017 revealed that Maharashtra and Odisha are emerging as the leading states in mushroom production. He also stated that mushroom industry in India recorded an average annual growth rate of 4.3 percent. Major mushroom growing states in India are Punjab, Madhya Pradesh, Maharashtra, Himachal Pradesh, Goa, Tamil Nadu and Kerala (Indian Agriculture, 2003).

Verma (1999) [115], stated that Punjab alone produces 20-25% mushrooms out of total production in India. The state of Haryana ranks third in producing mushroom which has produced 6164 tonnes of mushrooms during 2007 and it has set a target of producing 7000 tonnes of mushroom for 2008. According to Lakshmipathy *et al.* 2012, commercial milky white mushroom growers are mostly confined to Tamilnadu, particularly in Erode, Salem, Coimbatore, Trichy, Madurai and other districts. Sharma *et al.* 2011 stated that Punjab alone produces 14 % mushroom out of total production in India. The state of Haryana ranks third in producing mushroom which has produced 6164 tonnes of mushrooms during the 2007 and it has set a target of producing 7000 tonnes of mushroom for 2008.

Mushrooms are consumed in many parts of the world today, their cultivation being centuries old. According to Belewu, 2001. Belewu and Ademilola, 2002 [15, 16], Belewu, 2003 [17], and Belewu and Lawal 2003, the cultivation of mushroom in agricultural waste was found that in rice husk, sorghum stover, sawdust, gliricidia mixture and suitable substrates for the cultivation of edible mushroom. While rice straw, coir, cotton waste, sugarcane leaves, sugarcane baggase, water lilly and banana leaves are equally implicated (Sarker *et al.* 2008 [100]. Belewu and Belewu, 2005) [19].

Pleurotus is a versatile genus belonging to white -rot basidiomycete fungi and well known for their complexity of the enzymatic system and prominent lignocellulolytic property, member of this genus can colonize a wide range of natural lignocellulosic waste. (Naraian *et al.* 2016) [72]. According to Rosado *et al.* (2002) [92], oyster mushroom can grow at moderate temperatures, ranging from 20 ° to 30 °, and at a humidity of 55-70 % on various agricultural waste materials used as substrate, which is more cultivated than any other mushroom species because of its flexible nature. Shashirekha *et al.* (2005) [103], stated that when cultivating *Pleurotus florida*, the incorporation of cotton seed powder into rice straw substrate enhanced mushroom yield, increased net and total protein free aminoacids and total lipids content, while there was a significant decrease in total dietary fibre, free sugars and polymeric carbohydrates. Rodriguez *et al.* (2007) [90]. Reported that *P. eryngii* fruiting body yields were significantly higher in substrates containing Mn (50 ug/g) and soyabean than in the basal cotton seed hull/saw dust substrata. According to Obodai *et al.* (2003) [77]. *P. ostreatus* BE is much lower when it is cultivated on fresh saw dust than on composted saw dust/bran mixture. According to Wang *et al.* (2001), *Pleurotus ostreatus* cultivated on spent grain substrate had a higher nutritional value than those grown on other types of substrates. Moonmoon (2010), developed different strains of

King Oyster mushroom (*Pleurotus eryngii*) on sawdust and rice straw in Bangladesh.

Naraian *et al.* (2017) [72], successfully cultivated three strains of oyster mushrooms like *Pleurotus florida*, *P. sajor-caju* and *P. eous* on cattail weed substrata. According to Arini *et al.* (2016), Grey oyster mushroom (*Pleurotus Sajor-caju*) is one of the edible mushrooms from *Pleurotus* family, which is cultivated on rubber sawdust commercially in Malaysia.

According to Md. Asaduzzaman *et al.* 2008, seven agricultural wastes like sawdust, coir, sugarcane baggase, sugar cane leaves, cotton waste, banana leaves and rice straw were used as substrate or nutrient source for the production of mushroom (*Pleurotus florida*) to investigate the nutritional composition of mushroom.

According to Lalithadevy *et al.* (2014) [59], Oyster mushroom (*Pleurotus florida*) was cultivated in different fruits and vegetables peel (Sweet lime, Water melon, banana, pomegranate, onion, green plantain, potato and tapioca) alone and in combination of different proportion with paddy straw to assess the yield performance.

Nutritional and therapeutic profile of mushrooms

Mushrooms stands as one of the world's greatest untapped resources of nutritious food. (obodai *et al.* 2003) [77]. Ranote *et al.* (2007) [89], reported that earlier it was believed that mushrooms are devoid of nutrients but now researchers have proved mushrooms as a nutritionally sound food of great value and can be considered as meat for vegetarians. Stamets (2000) [108], stated that the use of mushroom as food is probably as old as civilization and mushrooms currently have greater importance in the diet of mankind.

Mushrooms fall between high grade vegetables and low-grade meats provides about 35 calories/100 gm (Singh *et al.* 2001) [107]. According to Nita (2009) [75], mushrooms are cheap source of high-quality proteins, vitamins, fibres, antioxidant and water and several growth promoting substances and also add flavor to the vegetarian diet.

According to Sadler 2003, the high protein content in mushrooms makes them an ideal food because they contain all the essential aminoacids and are especially rich in lysine and leucine which lacks in most staple cereal foods. Mushrooms being a complete food source as rich in proteins, vitamins, fats, carbohydrates, dietary fibres and minerals (Alam and Raza, 2001) [5]. Pavel, 2009 reported that mushrooms are considered as a potential substitute of muscle protein on account of their high digestibility.

According to Adejumo and Awosanya (2005) [1] the energy value of mushroom varies according to species which is about equal to that of an apple. Beelan *et al.* 2004 stated that carbohydrates are in the form of glycogen, chitin and hemicellulose instead of starch as in plants. Among sugars, trehalose which is called the mushroom sugar and sugar alcohol ie mannitol play a key role in fruit body formation. Beelman (1987) [14] reported that fresh mushrooms contain about 0.9 % of mannitol and hemicellulose 0.28 % of reducing sugar and 0.59 % glycogen. Mushroom is a low fat food, containing 1-2 % fat on dry weight basis, Mushrooms contain all the classes of lipids including free fatty acids, glycerides, sterols and phospholipids (Kumar and Murthy, 2002) [52]. It is clear that 72 % of the total fatty acids in mushrooms are unsaturated. The high unsaturation is due to the presence of linolenic acid and it does not contain cholesterol at all (Chang and Mshigeni, 2001) [23].

Folic acid and vitamin B12 which are absent in most vegetables are present in mushrooms (Cheung, 2011). Holick (2007) ^[40], states that mushroom are non-animals natural source of vitamin D. Researchers showed that artificial UV light technologies were equally effective for vitamin D production as in mushrooms exposed to natural sunlight (Koyyalamudi *et al.* 2009) ^[53]. Among several species of cultivated mushrooms, *Pleurotus ostreatus* has been popularly consumed by people all over the world due to their taste, flavor, high nutritional and medicinal values (Deepalakshmi and Mirunalini, 2014) ^[27]. According to Yang *et al.* 2002 and Lo *et al.* 2005 had reported that fruiting bodies of *Pleurotus* possessed higher concentration of antioxidants than other commercial mushrooms. Oyster mushroom contain most of the mineral salts required by the human body (stephanie, 2002) ^[110].

The nutritive and medicinal values were known as early as 1500 BC based upon many ancient literatures (Sagakami *et al.* (1991) and Wasser *et al.* (1999) ^[119]). Extensive work on medicinal attributes of *Pleurotus* was done by Wang, Li and their colleagues in the first decade of the new millennium (Wang *et al.* 2004 ^[118]., Li *et al.* 2008., Gregori *et al.* 2007) ^[37]. Later Gregori *et al.* (2007) ^[37] updated and reviewed the nutritional and medicinal values of *Pleurotus* species. Recently Khan and Tania (2012) ^[51] reported the nutritional and medicinal aspects of *Pleurotus* species.

According to Akyuz *et al.* 2010 ^[3]. Oyster mushroom has been explored to combat simple and multiple drug resistant isolates of *Escherichia coli*, *Staphylococcus epidermidis* and *S.aureus*. Iwalokun *et al.* 2007 ^[43], reported that antimicrobial and antifungal activity of oyster mushroom depended upon the nature of the solvent, ether extract were more active against gram negative bacteria as compared to acetone extract. Ether and acetone extracts of oyster mushroom was effective against *B.Subtilis*, *E.coli* and *S.cerevisiae*. Later Nithya and Rangunathan (2009) ^[76], stated that using extracts of *P. sajor-caju* have higher antibacterial activity against *Psuedomonas aeruginosa* and *E.coli* when compared with the Gram positive organism *S.aureus*. According to Mau *et al.* 2001 ^[65]., Yang *et al.* 2002 ^[123]., Lo *et al.* 2005, fruiting bodies of *Pleurotus* possessed higher concentration of antioxidants than other commercial mushrooms.

Bobek *et al.* 2001 ^[20], stated that antioxidant activity of mushrooms was mainly due to the presence of polysaccharide pleuran that has been isolated from *P.ostreatus* showing a positive effect on rat colon with pre-cancerous lesions. Lee *et al.* 2000 ^[60], Jose *et al.* 2002 ^[46, 47], 2004, Mau *et al.* 2002 ^[123] reported that fruiting bodies of oyster mushroom have higher phenolic concentration when compared with mycelium and fermentation broth filtrate of *P.citrinopileatus*.

Polysaccharide extracted from mycelium of *P. sajor-caju* exhibited antineoplastic activity (Zhuang *et al.* 1993) ^[126]. According to Chatterjee *et al.* 2011 ^[24], the extracts from mushrooms including species *Pleurotus* may modulate the response of host immune system; in particular, various mushroom polysaccharides are likely to effect promotion and progression stages towards cancer.

Filipic *et al.* 2002 tested extracts of 89 different mushrooms species for their antigenotoxic and bio-antimutagenic activities on *S. typhimurium* and *E. coli* amongst them *P. cornucopiae* was found to be most effective. Lakshmi *et al.* 2004 stated that methanolic extracts of *P. ostreatus* var.

florida showed significant inhibition of mutagenicity elicited through mutagens requiring activation According to Chatterjee *et al.* 2011 ^[24], extracts from mushroom including species *pleurotus* may modulate the response of host immune system, in particular, various mushroom polysaccharides are likely to affect promotion, progression stages towards cancer .The antitumor properties of mushroom derived glucan were reviewed by Wasser (2002) ^[120]. Many more reports are available indicating that oyster mushroom possesses antitumor activity (Sarangi *et al.* 2006 ^[99]; Gu *et al.*, 2006).

According to Kim *et al.* (1997) ^[52], endo-polymer from submerged mycelial cultures of *P. ostreatus* possesses hypoglycemic effects. Yuan *et al.* (1998) ^[124], stated that high fibre and protein content and low fat content of edible mushrooms make it ideal food for diabetic patient.

Sachin *et al.* 2006 ^[95]. Reported that aqueous extracts of *P.pulmonarius* upon oral administration decreased serum glucose level in alloxan treated diabetic mice. Polysaccharides extracted from fruiting body of *P.citrinopileatus* alleviated anti-hyperglycemic effect by the elevation of the activity of glutathione peroxidase (Hu *et al.* 2006). According to Windholz (1983) ^[122], guanide, a compound related to the bi-guanide class of oral anti-diabetic drugs was isolated from the *Pleurotus* species that exerted anti-hypoglycemic effect.

Post-harvest changes and storage conditions in the shelf life of mushrooms

According to Rai and Arumuganathan (2008), post-harvest losses are very high in most of the horticultural commodities and it may be one of the highest in mushrooms. The most damaging post-harvest changes in mushrooms differs with species -it is blackening in the button mushroom, cap opening in the paddy straw mushroom and mucilage in the oyster mushroom, which affect their marketability significantly (Beelman., 1987) ^[14].

Fresh mushroom is highly perishable and deteriorates immediately after harvest (Kumar *et al.* 2014). When compared to most vegetables, mushrooms possess a short post-harvest shelf life, due to a very high metabolic activity and high water content, making them prone to microbial spoilage and to exhibit enzymatic browning. After harvest the colour of mushroom gradually changes from white to brown, due to the appearance of browning and possibly bacterial blotching, while the growth of the stipe and the cap continuous. The cap growth results in gradual opening of the mushroom cap (Aguirre *et al.* 2009) ^[2].

According to Mehta *et al.* 2011 the presence of more than 90 % moisture content of mushrooms indicate that, they are highly perishable and start deteriorating immediately after harvest. Weight loss, browning, veil opening, and microbial spoilage are the most common post-harvest changes in the mushrooms which often result into enormous economic losses (Rai and Arumuganathan, 2008).

Mushrooms have very short shelf life-these cannot be stored or transported for more than 24 hours at the ambient conditions prevailing in most parts of year in the country (Kaushal and Sharma, 1995) ^[50]. According to Ares *et al.* 2006 ^[8]; Parentelli *et al.* 2007 ^[79], an important cause of loss of mushroom quality during post-harvest storage is browning. Enzymatic browning is a consequence of PPO catalyzed oxidation of phenolic substrates into quinones, which undergo further reactions to dark pigments called

melanin. The major PPO enzyme responsible for browning in mushrooms appears to be tyrosinase (Jiang *et al.* 2011)^[44]. The activity of tyrosinase, responsible for mushroom browning was dependent on oxygen concentration (Antmann *et al.*, 2008)^[7].

Dhar, 1992 stated that weight loss is a very serious problem in all the mushrooms as these contain very high moisture (85-90 %) and are not protected by the conventional cuticle. Mohapatra *et al.* 2010 reported that short shelf span of mushrooms is due to their high respiration rate and thus they have the tendency to turn brown and lack of physical protection to avoid water loss or microbial attack and which is the major cause of quality losses that accounts for reduction in market value. According to Sharma and Dhar, (2010)^[28], loss of texture, development of off flavor and discoloration results in poor marketable quality and restricts trade of fresh mushrooms.

Kaur and Kapoor, 2002 are of the opinion that fresh foods which are in excess supply during season and storage during the rest of the year is a phenomenon which invites attention to the development of technologies for appropriate processing and packaging. According to Gabriela *et al.* 2008^[35]. Borton *et al.* 1987^[21], modified atmosphere packaging (MAP) was demonstrated in some reports to be an effective method of extending the shelf life of pleurotus ostreatus and other mushroom varieties such as agaricus bisporus. The use of MAP technology cannot preserve the organoleptic quality at room temperature beyond one week stated by Jones *et al.* 1963., Zhang *et al.* 2006. Modified atmosphere can be defined as an atmosphere that is created by altering normal air composition, in order to provide an appropriate atmosphere surrounding the product for decreasing the deterioration rate and increasing the shelf life (Moleyar and Narasimham 1994^[70]., Phillips 1996^[82]., Farber *et al.* 2003)^[32].

Parentelli *et al.* 2007^[79] reported that shelf life of shiitake mushroom, both in modified atmosphere and macro perforated packages was limited by changes in its sensory characteristics, due to mushrooms metabolic activity and not by microbial growth. According to Tianjia *et al.* 2010^[112] mushroom packed and unwrapped in a conventional hard board box loose marketability early during the storage period due to weight loss, shrinkage browning and spore formation. Many works have focused on the use of chemical treatment to extend and improve the shelf life of fruits and vegetables stated by Guijarao *et al.* 2007, Wilawan *et al.* 2003^[121].

The influence of carbon dioxide in respiration rate depends on the product, its developmental stage, carbon dioxide concentration and time of exposure (Fonseca *et al.* 2002)^[24]. According to Phillips 1996 and Rooney 2000, recently for modified atmosphere packaging, smart packaging systems have been developed.

Value addition in mushroom and its importance

Value addition is a process of increasing the economic value and consumer value and consumer appeal of a commodity (Saima *et al.* 2014)^[98]. According to Nirmal *et al.* (1999)^[74], value added products are raw or pre-processed commodities whose value has been increased through the additional ingredients or processes that make the product more attractive to the buyer or more valuable by the consumer. As per the USDA (2010) definition value added

agriculture products are characterized by one or more of the following criteria:

1. A change in the physical state/form of the product.
2. The product is produced in such a way that, the enhancement of its value is demonstrated through a business plan.

Anand (2000)^[6], stated that food are perishable commodities and are therefore processed to preserve them from deterioration while providing the consumer with palatable, wholesome, nutritious and tasty food inconvenient form throughout the year. Rai and Athwali 2000 reported that more and more people are going for processed food and it was estimated that over 10% of total expenditure incurred in the household for foods is spent on processed food.

According to Mallaya (2003)^[64], food processing is very important for the prosperity of India. Food processing industry helps to avoid post harvesting losses of agricultural products in India. Value addition of the food production is only 7% in India compared to 23% in China, 45% in Philippines though we have gone along way in improving our food production. Kaur and Kapoor (2002)^[49], are of the opinion that fresh foods which are in excess supply during season and storage during the rest of the year is a phenomenon which invites attention to the development of technologies for appropriate processing and packaging.

NAAS (2006) stated that increased productivity demands proper post-harvest infrastructure to increase shelf life and marketability. The consumption of mushrooms throughout the year, particularly of species harvested in nature habitats is made possible through the use of appropriate processing and value addition (Czapski, 2006). In view of their highly perishability nature, the fresh mushrooms have to be processed to extend their shelf life for off season use. This can be achieved by adopting appropriate post-harvest technology to convert surplus mushrooms into novel value added products. The value added products are needed by the mushroom growers not only to reduce the losses but also to enhance the income by value addition and boost the consumption of this important horticultural crop (Gopinath *et al.* 2013)^[36]. Suslow and Cantwell (1998) postulates that the highly perishable nature of fresh mushrooms is the limiting factor for mushroom marketing. Quality deterioration starts just after harvesting. Therefore producers are not able to hold it fresh for more days to market. Processing into value added products is one option producers can adopt to save the product from spoilage.

In India, the mushroom market is largely the contribution of small and marginal farmers with limited resources who are dependent on local markets for the sale of their produce (Wakchauri *et al.* 2010). Progressive farmer (2002) stated that there is going to be good demand for processed and value added foods and serious thoughts has to be given to bring product diversification and mushroom processing in order to compete in the international market. Considerable quantities of mushrooms are lost during glut period. Hence in order to stabilize production, it is of interest to device techniques for the production of different value added mushroom products to meet the year round demand (Bano *et al.* 1997)^[12].

According to FAO (2004), because of the perishable nature of mushrooms, sellers are forced either to sell their unsold

Fresh produce at the end of the day for a low price, or dry it before it perishes. Processing can assist marketing by extending shelf life for small scale producers until they need to sell their product and also by adding value (Steinbuch, 1986)^[109].

Unprocessed mushrooms take up a lot of room and this can be a costly way of preserving them. By making value added products, it can be stored in an economic viable way (Elaine and Nair, 2009)^[30]. Mushrooms are gaining immense popularity and the consumer led to the development demand for variety has of the readymade or value added processed foods from mushrooms (Kumar and Rai, 2007).

Preparation of nutritive ready to serve beverages is considered to be suitable and economic substitute for utilization of mushroom squash (Bala *et al.* 2009)^[11]. Rai and Arumuganathan (2008), studied the value added products from the mushroom. Various mushroom powder value added products such as biscuit, soup powder, nuggets, noodles, papads, candies, pickles, ketchup and murraba etc, have been prepared. Shick *et al.* (2010)^[104], studied the effect of powdered mushroom on the quality of the cake and have noted that 15 % addition level has best acceptability.

Paul (2016)^[80], studied on the standardization and properties of various products from mushroom powder. Arumuganathan *et al.* 2005 reported that the value addition of oyster mushrooms into chips could provide solution as long term storage of mushroom upto three months of storage without affecting the organoleptic quality of the product. Good quality crunchy oyster mushroom biscuits which can be comparable with commercially available biscuits in terms of appearance and taste were successfully prepared and it also showed good storage stability (Wakchaure *et al.* 2010)^[116].

Conclusions

In India mushroom cultivation is becoming successful because of the low capital investment involved as mushroom can be grown on any substrate prepared from clean agricultural waste material. The technology can be profitable considered in areas where limited land and agriculture residues are available abundantly. Moreover mushroom cultivation technology is friendly to the environment. Mushrooms are gaining importance in today's healthy diet with regards to their good digestibility and nutritional qualities. It can directly improve livelihoods through economic, nutritional and medicinal contributions. The highly perishability nature of fresh mushroom is the limiting factor for the producers to hold it fresh for more days to market. Considerable quantities of mushroom are lost during glut period. In order to extend the shelf life, adopting appropriate packaging materials, storage conditions and processed the mushrooms into novel value added products is a big avenue in itself, which will be more profitable and also employment generating. The value added products based on mushrooms are also gaining immense popularity among consumers as they ensure off season availability of this nutrient rich diet. Thus the effect of value addition in mushroom could tackle the problem of malnutrition prevalent in various developing countries.

References

1. Adejumo TO, Awosanya DB. Proximate and mineral composition of four edible mushroom species from

- South Western Nigeria. *Afr. J. Biotechnol.* 2005; 4(10):1084-1088.
2. Aguirre I, Frias JM, Barry-Ryan C, Grogan H. Modelling browning and brown spotting of mushrooms (*Agaricus bisporus*) stored in controlled environmental conditions using image analysis. *J. Food Eng.* 2019; 91:280-286.
3. Akyuz MAN, Onganer N, Erecevit P, Kirbag S. Antimicrobial activity of some edible mushrooms in the eastern and southeast Anatolia region of Turkey. *GU J.Sci.* 2010; 23(2):125-130.
4. Akyuz MAN, Onganer N, Erecevit P, Kirbag S. Antimicrobial activity of some edible mushrooms in the eastern and southeast Anatolia region of Turkey. *GU J.Sci.* 23(2):125-130.
5. Alam DSM, Raza MS. Importance of mushrooms. NIA, TandoJam, Pakistan. *alternative medicine.* Oxford University press. 2001; 2(3):285-299. Available at: <http://www.hindawi.com/journals/ecam/2005/906016/citations/>
6. Anand KJ. Food processing in India. *Fd.Ind.* 2002; 19(6):85-90.
7. Antmann G, Are G, Lema P, Lareo C. Influence of modified atmosphere packaging on sensory quality of shiitake mushrooms. *Post-harvest Biol. Technol.* 2008; 49:164-170.
8. Ares G, Parentelli C, Gambaro A, Larco C, Lema P. Sensory shelf life of Shiitake mushrooms stored under passive modified atmosphere. *Post-harvest Biol. Technol.* 2002; 41:191-197.
9. Arini N, Mohd Rashidi, Tajul AY. Nutritional and antioxidant values of Oyster mushroom (*P. Sajor-Caju*) cultivated on rubber sawdust. *International Journal on Advanced Science Engineering Information Technology.* 2016; 6(2):2088-5334.
10. Arumuganathan T, Rai RD, Hemkar AK. Studies on development of value added products from fresh button mushroom (*Agaricus bisporus*). *Mushroom. Res.* 2005; 14(2):84-87.
11. Bala BK, Morshed MA, Rahman MF. International Solar Food processing conference, 2009.
12. Bano Z, Rajarathanam S, Shashirekha MN, Ghosh PK. Post Harvest Physiology, Quality and storage of fresh mushrooms: Advances in mushroom biology and production. Mushroom society of India, National Research Centre for Mushroom, Solan. 19997; 321-337
13. Beelan RB, Royse D, Chikthimmah N. Bioactive components in *Agaricus bisporus* of nutritional, medicinal or biological importance. *Intr. J. Medicinal Mushrooms.* 2004; 5:321-337.
14. Beelman R. Factors influencing post harvesting quality and shelf life of fresh mushrooms. *Mushroom News,* 1987.
15. Belew MA, Ademilola. Digestibility response of WAD goats to mushroom (*Volvariella volvacea*) treated cotton waste. *Moor J. Agri Res.* 2002; 3(1):83-86.
16. Belew MA, Belew KY. Cultivation of mushroom (*Volvariella volvacea*) on banana leaves. *Afri. J. Biotechnol.* 2002; 4(12):1401-1403.
17. Belew MA, Lawal RA. Studies of the cultivation of edible mushroom (*Pleurotus pulmonarium*) on cocoa bean shell and saw dust (*Gilircidia mixture*). *Res.* 2003.
18. Belew MA. Effect of fungus (*Volvariella volvocea*) treated cotton waste as a replacement for cotton seed

- cake and meal by WAD goat. *Trop. J. Anim. Sci.* 2001; 4(1):93
19. Belew MA. Nutritional qualities of corn cobs and waste paper incubated with edible mushroom (*Pleurotus sajor caju*). *Nig. J. Anim prod.* 2003; 30(1):20-25.
 20. Bobek P, Galbavy S. Effect of pleuran on the antioxidant status of the organism and on dimethylhydrazine induced precancerous lesions in rat colon. *Brit. J. Biomed. Sci.* 2001; 58:164-168.
 21. Borton KS, Frost CE, Nichols R. A combination of plastic permeable film system for controlling post-harvest mushrooms quality. *Biotechnol. Lett.* 1987; 8(9):529-534.
 22. Chang ST, Wasser SP. The cultivation and Environmental impact of mushrooms. Printed from the oxford Research Encyclopedia, Environmental Science(c) Oxford University Press, USA, 2017, 43.
 23. Chang ST, Mshigeni KE. Mushroom and their human health; their growing significance as potent dietary supplements. The University of Namibia, Windhoek, 2001, 1-79.
 24. Chatterjee S, Biswas G, Basu SK, Acharya K. Antineoplastic effect of mushrooms: a review, *A.J. Crop. Sci.* 2011; 5(7):904-911.
 25. Cheung PCK. Functional properties of edible mushrooms. *J. Nutr.* 2011; 128:1512-1516.
 26. Czapski J. Mushrooms quality as affected by washing and storage conditions. *Vegetable crops research bulletin.* 2002; 56:121-128
 27. Deepalakshmi K, Mirunalini S. *Pleurotus Ostreatus*: an oyster mushroom with nutritional and medicinal properties. *Journal of Biochemical Technology.* 2014; 5(2):718-726.
 28. Dhar BL. Post-harvest storage of white button mushroom (*Agaricus bitorquis*). *Mushroom Research.* 1992; 1:127-130.
 29. Dung NTP, Tuyen DB, Quang PH. Morphological and genetic characteristics of oyster mushroom and conditions affecting on spawn growing. *International Food Research Journal.* 2012; 19:347-352.
 30. Elaine M, Nair NGT. Rural Infrastructure and Agro-Industries. Food and Agriculture Organization of the United Nations. Diversification booklet number 7, Rome, 2009. FAO Stat. <http://faostat.org/site/567.30/1/2013>.
 31. FAO (Food and Agricultural Organization). *Wild Edible Fungi, a global overview of their use and importance to people.* E. Boa, Non Wood Forest Products, 2014, 17.
 32. Farber JN, Harris IJ, Parish ME, Beuchat IR, Suslow TV, et al. Microbiological safety of controlled and modified atmosphere packaging of fresh and fresh cut produce. *Comprehensive Reviews in Food Science and Food Safety.* 2003; 2:142-160.
 33. Filipic M, Umek A, Mlinaric A. Screening of basidiomycete mushroom extracts for antigenotoxic and bio-antimutagenic activity. *Die Pharmazie.* 2002; 57:416-420.
 34. Fonseca SC, Oliveira AR, Brecht JK. Modeling respiration on rate of fresh fruits and vegetables for modified atmosphere packages: a review. *Journal of Food Engineering.* 2002; 52:99-199.
 35. Gabriela A, Gaston A, Patricia I, Claudia I. Influence of modified atmosphere packaging on sensory quality of shiitake mushrooms. *Post-harvest. Biol. Technol.* 2008; 1(49):164-170.
 36. Gopinath L, Arunkumar J, Meera A, Shantha PR. Studies on different drying, canning and value addition techniques for mushrooms (*Calocybe Indica*). *Afr. J. Food Sci.* October. 2013; 7(10):361-367.
 37. Gregori A Svagelj, Pohleven J. Cultivation techniques and medicinal properties of *Pleurotus* spp. *Food Technol. Biotech.* 2007; 45:238-249.
 38. Gu YH, Sivam G. Cytotoxic effect of oyster mushroom *Pleurotus ostreatus* on human androgen independent prostate cancer PC-3 cells. *J. Med. Food.* 2006; 9:196-204.
 39. Guijarro B, Melgarajo P, De CA. Effect of stabilizers on the shelf life of penicillium frequentans conidia and their efficacy as a biological agent against peach brown rot. *Int. J. Food Microbiol.* 2007; 2(113):117-124.
 40. Holick MF. Vitamin D Deficiency. *N. Engl. J. Med.* 2007; 357:266-281.
 41. Hu SH, Liang ZC, Chia YC, Lien JL, Chen KS, Lee MY, et al. Antihyperlipidemic and antioxidant effects of extracts from *Pleurotus citrinopileatus*. *J. Agric. Food. Chem.* 2006; 54:2103-2110
 42. Indian Agriculture. Indian Economic Data Research Centre, New Delhi.
 43. Iwalokun BA, Usen AA, Otunba and Olukoya DK. Comparative phytochemical evaluation, antimicrobial and antioxidant properties of *Pleurotus ostreatus*. *Afri. J. Biotechnol.* 2007; 6:1732-1739.
 44. Jiang T, Zheng X, Li J, Jing G, Cai L, Ying T. Integrated application of nitric oxide and modified atmosphere packaging to improve quality retention of button mushroom (*Agaricus bisporus*). *Food Chemistry.* 2011; 126:1693-1699.
 45. Jones D, White RC, Gibbs E. Influence of blanching or brining treatments on the formation of chlorophyllides pheophytins and pheophorbides in plant material. *J. Food Sci.* 1963; 28:433-439.
 46. Jose N, Ajith Ta, Jananrdhanan. Antioxidant, anti-inflammatory and antitumor activities of culinary - medicinal mushroom. *Pleurotus pulmonarius* (Fr.) Quel. (*Agaricomycetideae*). *Int. J. Med. Mush.* 2002; 4:329-335.
 47. Jose N, Ajith TA, Jananrdhanan. Methanol extract of the oyster mushroom, *Pleurotus florida*, inhibits inflammation and platelet aggregation. *Phytotherapy Res.* 2004; 18:43-46.
 48. Kamal ASM, Khair A, Farhad SFU, Zaman NA Fauziya. Mechanical detection of minerals, heavy metals and trace elements in processed mushroom in relation to toxicological aspects. *Bangladesh. J. Mushrooms.* 2009; 3(1):53-65.
 49. Kaur C, Kapoor HC. Processed fruits and vegetables are healthier. *Indian. Hort.* 2002; 47(3):35-36.
 50. Kaushal LBB, Sharma KD. Post-Harvest Technology of Mushrooms. In: Chadha, K.C and Sharma, S.R (eds). *Advances in Horticulture. Vol 13-Mushroom*, Malhotra Publishing House, New Delhi, 1995, 123-126
 51. Khan MA, Tania M. Nutritional and medicinal importance of *Pleurotus* mushroom: An overview. *Food Review Int.* 2012; 28(3):313-329.
 52. Kim MY, Park MH, Kim GH. Effects of mushroom protein bound polysaccharides on the blood glucose

- levels and energy metabolism in streptozotocin-induced diabetic rats. *J. Kor. Nutr.* 1997; 30:743-750.
53. Koyyalamudi SR, Jeong SC, Song CH, Cho KY, Pang G. Vitamin D2 formation and bioavailability from *Agaricus bisporus* button mushrooms treated with ultraviolet irradiation. *J. Agri. Food Chem.* 2009; 57(8):3351-3355.
 54. Kumar K, Rai BA. Studies on development and shelf life of pickle of button mushroom (*Agaricus bisporus* L.). *Haryana J. hort. Sci.* 2007; 36(3-4):244-246.
 55. Kumar RV, Murthy KNK. Nutritive value of mushrooms. *Agro Industry.* 2002; 4(2):17.
 56. Kumar S, Gireesh CJN, Srivastava Shamsher A. Post-harvest Technology of Button Mushroom: A Socio-Economic Feasibility. *J. Post-harvest Technol.* 2014; 2(2):136-145.
 57. Lakshmi B, Jose N, Ajith TA, Jananrdhanan KK. Antimutagenic activity of methanolic extract of culinary medicinal oyster mushroom, *Pleurotus ostreatus* (Jacq: Fr.) Kumm. (strain florid Eger nom. Nud) and its protective effect against benzo(a) pyrene-induced hepatic damages. *Int.J.Med. Mush.* 2004; 6:139-149.
 58. Lakshmi G, Jayakumar A, Meera A, Raj SP. Optimization of growth parameters for increased yield of the edible mushroom *Calocybe indica*. *Afri. J. Biotec.* 11(11):7701-7710.
 59. Lalithadevy V, Josephine NM. Yield performance of fruits and vegetables peel as substrates for the cultivation of oyster mushroom (*Pleurotus florida*). *Journal of Innovative Research and Solution* 2014; (1):220-226.
 60. Lee EW, Kawagishi H, Sugiyama K. Suppression of D-galactosamine induced liver injury by mushroom in rats. *Biosci. Biotech. Biochem.* 2000; 64(9):2001-2004.
 61. Li YR, Liu H, Wang X, Ng TB. A novel lectin with potent antitumor, mitogenic and HIV-1 reverse transcriptase inhibitory activities from the edible mushroom *Pleurotus citrinopileatus*. *Biochimica et Biophysica Acta(BBA)-General subjects.* 2008; 1780(1):51-57.
 62. Lindequist V, Neidermeyer TH, Julinch WD. The pharmacological potential of mushrooms; evidence based complementary and alternative medicine. Oxford University press. 2005; 2(3):285-299. Available at <http://www.hindawi.com/journals/ecam/2005/906016/cita>
 63. Lo SH. Quality evaluation of *Agaricus bisporus*, *Pleurotus eryngii*, *Pleurotus ferulae*, *Pleurotus ostreatus* and their antioxidant properties during post-harvest storage. Master's thesis National Chung Hsing University, Taichung, Taiwan, 2005.
 64. Mallaya RR. Recent trends in food industry with special reference to fruits and vegetables. *Indian Fd. Ind.* 2003; 22(1):45-48.
 65. Mau JL, Chao GR, Wu KT. Antioxidant properties of methanolic extracts from several ear mushrooms. *J. Agric. Food Chem.* 2001; 49:5461-5467.
 66. Mau JL, Lin HC Song. Antioxidant properties of several speciality mushrooms. *Food Res. Int.* 2002; 35:519-526.
 67. Md Asaduzzaman K, Mousumi T, Ruhul SM, Nadia A, Md Nazim U, et al. An investigation on the nutritional composition of mushroom (*Pleurotus florida*) cultivated on different substrates. *Bangladesh J. Mushroom.* 2008; 2(2):17-23.
 68. Mehta BK, Jain SK, Sharma GP, Doshi A, Jain HK. Cultivation of button mushroom and its processing; an techno-economic feasibility. *Int. J. Adv. Biotechnol. Res.* 2011; 2(1):201-207.
 69. Mohapatra D, Bira ZM, Kerry J, Frias jm, oliveira FAR. Post-harvest hardness and colour evolution of white button mushrooms (*Agaricus bisporus*). *J. FoodSci.* 2010; 75(30):146-152.
 70. Moleyar V, Narasimham P. Modified atmosphere packaging of vegetables an appraisal. *Journal of Food Science and Technology.* 1994; 31:267-278.
 71. NAAS. Employment Opportunities in Farm and non-farm sectors through technological interventions with emphasis on primary value addition .Policy Paper no. New Delhi, India, 2006.
 72. Naraian R, Singh P, Ram S. Supplementation of basal substrate to boost up substrate strength and oyster mushroom yield:an overview of substrates and supplements. *Int. J. Curr Microbiol App Sci.* 2016; 5:543-553.
 73. Narain R, Bharti D. Nutritional value of three different oyster mushrooms grown on cattail weed substrate. *Archives of Biotechnology and Biomedicine.* Heighten Science Publications Corporation, 2017.
 74. Nirmal Kapoor J, Vidhya P. New prospects in value addition. *J. Food Sci.* 1999; 122-124
 75. Nita M. Composition and health benefits of mushroom – a rich source of nutrients with medicinal properties. www.suile.101.com/content/composition and health benefits of mushroom, 2009.
 76. Nithya R, Ragunathan R. Synthesis of silver nanoparticle using *Pleurotus sajor-caju* and its microbial study. *Digest J. Nanomaterials and Biostructure.* 2009; 4(4):623-629.
 77. Obodai M, Cleland OJ, Vowotor KA. Comparative study on the growth and yield of pleurotus ostreatus mushroom on different lignocellulosic by-products. *J. Ind. Microbiol. Biotechnol.* 2003; 30:146-149.
 78. Omarini A, Nepote V, Grosso NR, Zygadlo JA, Alberto E. Sensory analysis and fruiting bodies characterization of the edible mushrooms, *Pleurotus ostreatus* and *polyporustenuiculus* obtained on leaf waste from the essential oil production industry. *International Journal of Food Science and Technology.* 2010; 45:466-474.
 79. Parentelli C, Ares G, Corona M, Larco C, Gambaro A, Soubes M, et al. Sensory and microbiological quality of shitake mushrooms in modified atmosphere packages. *J. Sci. Food Agri.* 2007; 87(9):1645-1652.
 80. Paul V. Mushroom Products. In; *Mushrooms of India.* (eds Sharma, S., Singh, M., Prasad, S. and Rathore, H.I, IIT Delhi. 2016; 1:254-262.
 81. Pavel K. Chemical composition and nutritional value of European species of wild growing mushrooms: A review. *Food Chemistry.* 2009; 113(1):9-16.
 82. Phillips CA. Review; Modified atmosphere packaging and its effects on the microbiological quality and safety of produce. *International Journal of Food Science and Technology.* 1996; 31:463-479.
 83. Prakasam V. Mundkur Memorial Lecture Award-Current scenario of mushroom research in India. *Indian phytopathology.* 2012; 65(1):1-11

84. Progressive Farmer. Value added concept helps farmers. Birmingham, A. L; Progressive Farmer, 2000. Available at: <http://progressivefarmer.com>
85. Rai LSm, Athwali MD. Index of nutritional quality of some selected Indian snacks. *Indian J. Nutr. Dietet.* 2000; 14:123-125
86. Rai RD, Chandrasekar V, Arumuganathan T. Post-harvest technology of mushrooms. In; *Current vistas in mushrooms Biology and production*-Proceedings of the III rd mushroom conference-2002 (Eds. R. C. Upadhyay, S. K. Singh, and R. D. Rai), 2003, 225-236.
87. Rai RD, Arumuganatha T. Economics for pickling. Post-Harvest Technology. Technical Bulletin, NRCM, Solan, 2008, 68-69.
88. Ramkumar L, Ramanathan T, Thiruvakkarasu, Arivuselvan N. Antioxidant and radical scavenging activity of nine edible mushroom extract. *Intr. J. Pharmacol.* 2011; 6(6):950-953.
89. Ranote SP, Bawa AS, Chawl R. Edible mushrooms-Nutrition and Health Attributes. Tech reviews. *Indian Food Industry*, 2007.
90. Rodriguez Estrada AE, Royse DJ. Yield size and bacterial blotch resistance of *Pleurotus eryngii* grown on cotton seed hulls/oak sawdust supplemented with manganese, copper and whole ground soyabean, *Bioresour. Technol*, 2007, 1898-1906
91. Rooney M. Active and intelligent packaging of fruits and vegetables. In Day BPF(Ed). Processing of the International conference on fresh cut produce. 1999 sept 9 to 10. Campden & Chorley Food Research Association, Chipping Campden, Glos, UK, 2002.
92. Rosado FR, Carbonero ER, Kemmelmeier C, Tischer CA, Gorin PAJ, Iacomini M, et al. A partially 3-O-methylated (1-4) linked α -D-galactan and α -D-mannan from *Pleurotus ostreatus* Sing. *FEMS Microbiology Letter.* 2002; 212:261-265. DOI:10.1111/j.1574-6968.tb11276.
93. Rosli WIW, Solihah MA, Mohsin SSJ. On the ability of oyster mushroom (*Pleurotus sajou caju*) conferring changes in proximate composition and sensory evaluation of chicken patty. *International Food Research Journal.* 2011; 18(4):1463-1469
94. Royse DJ, Baars J, Tan Q. Current overview of mushroom production in the world Edible and Medicinal Mushrooms: Technology and applications, First edition. John Wiley & Sons Ltd, 2017, 5-13.
95. Sachin LB, Shweta NS, Naimesh MP, Prasad AT, Subhash LB. Hypoglycemic activity of aqueous extract of *Pleurotus pulmonarius* in alloxan-induced diabetic mice. *Pharmaceuti. Biol.* 2006; 44(6):421-425.
96. Sadler M. Nutritional properties of edible fungi. *Br. Nutr. Nutr. Bull.* 2003; 28:305-308.
97. Sagakami HT, Aohi A, Simpson, Tanuma S. Induction of immunopotential activity by a protein-bound polysaccharide PSK. *Anticancer Res.* 1991; 11:993-1000.
98. Saima P, Bushra I, Humaira K, Shazia S, Azhar MA. Value addition; A tool to minimize the post-harvest losses in horticultural crops. *Greener J. Agri. Sci.* 2014; 4(5):195-198.
99. Sarangi I, Ghosh D, Bhutia SK, Mallick SK, Maaiti TK. Anti-tumor and immunomodulating effects of *Pleurotus ostreatus* mycelia-derived proteoglycans, *Int. Immunopharmacol.* 2006; 16:1287-1297.
100. Sarker NC, Hossain MM, Sultana N, Mian IH, Karim AJMS, Amin SMR, et al. Relationship between nutrient content in substrates and economic yield of oyster mushroom (*Pleurotus ostreatus*). *Bangladesh J. Mushroom.* 2008; 2(1):27-33.
101. Sharma RK, Dhar BL. Mushroom cultivation: A highly remunerative crop for Indian farmers. *Indian Farming (New Direction)*, 2010, 201-207.
102. Sharma VP, Annepu SK, Gautam Y, Singh M, Kamal S. Status of mushroom production in India. *Mushr. Res.* 2017; 26(2):111-120.
103. Shashirekha MN, Rajarathnam S, Bano Z. Effects of supplementing rice straw growth substrate with cotton seeds on the analytical characteristics of the mushroom, *Pleurotus florida*. *Food Chem.* 2005; 255-259.
104. Shick M, Kumar, AMA, Islam A, Mahomud MM. The effect of mushroom powder on the quality of cake. *Progress Agriculture.* 2010; 21(1-2):205-214.
105. Singh MP, Kaur S, Sodhi HS. Evaluation of *Agaricus bisporus* Lange (sing.) strains in the plains of Punjab, India. *Int. J. Current. Microbiol. Appl. Sci.* 2017; 6(12):3417-3425.
106. Singh Manjit Shwet Kamal, VP Sharma. Status and trends in world mushroom production -1. *Mushroom Research.* 2017; 26(1):1-20.
107. Singh Sudhir K, Maharaj N, Kumbhar BK. Effect of drying air temperatures and standard pretreatments on the quality of fluidized bed dried button mushroom (*Agaricus bisporus*). *Indian Food Packer.* 2001; 55(5):82-86
108. Stamets P. Growing Gourmet and Medicinal Mushrooms. Ten speed press, Berkeley and Toronto, 2000, 339.
109. Steinbuch E. Some developments of mushroom processing. In; Proc. Inter. sym. scientific and technical aspects of cultivating edible fungi. The Penna State Univ, 1986, 311-318.
110. Stephanie, I. 2002. The real nutritional value of fungi. United Kingdom; Cancer Research. UK, 2002, 9-21.
111. Suslow T, Cantwell M. Mushrooms. Fresh produce Facts. Available: <http://www.Postharvest.ucdavis.edu>.
112. Tianjia J, Shasha L, Qiupin C, Lirong S, Tiejun Y. Effect of integrated application of gamma irradiation and modified atmosphere packaging of physicochemical and microbiological properties of Shiitake mushroom (*Lentinus edodes*) *Food Chem.* 2010; 3(122):761-767.
113. United Nations. Millennium Development Goals. United Nation, New York USA <http://un.org/millenniumgoals>, 2000.
114. USDA. A National information resource for value added Agriculture. US Department of Agriculture, Rural Business Development, Washington, DC, 2010.
115. Verma RN. National and international scenario of mushroom production and trade. Paper presented at conference on mushroom industry in India-A decade of achievements and future perspective on, 1999, 5-8.
116. Wakchaure GC, Shirur M, Manikandan K, Rana L. Development and evaluation of oyster mushroom value added products. *Mushroom Research.* 2010; 19(1):40-44.
117. Wakchaure GC. Production and marketing of mushrooms. Global and National Scenario. In:

- Mushroom Cultivation, marketing and consumption. Directorate of Mushroom Research, ICAR, Solan(H.P), 2011, 15
118. Wang HX, Ng TB. Purification of a novel low-molecular mass laccase with HIV-1 reverse transcriptase inhibitory activity from the mushroom *Tricholoma giganteum*. *Biochem. Biophys. Res. Commun.* 2004; 35:450-454.
 119. Wasser SP, Weis AL. Medicinal properties of substances occurring in higher Basidiomycetes mushrooms: Current perspectives (Review). *Int. J. Med. Mush.* 1999; 1:31-62.
 120. Wasser SP. Medicinal mushrooms as a source of antitumor and immunomodulating polysaccharides. *Appl. Microbiol. Biotechnol.* 2002.
 121. Wilawan K, Yoshie M, Yukio H. Inhibition of *Aspergillus* rot by sorbitol in apple fruit with watercore symptoms. Post-harvest. *Biol. Technol.* 2003; 2(29):121-127.
 122. Windholz M. The Merck Index: An encyclopedia of chemicals, drugs and biologicals, 10 th ed. Merck and Co, New Jersey, 1983.
 123. Yang JH, Lin HC, Mau LJ. Antioxidant properties of several commercial mushrooms. *Food Chem.* 2002; 77:229-235.
 124. Yuan ZM, He PM, Cui JH, Takeuchi H. Hypoglycemic effect of water-soluble polysaccharide from *Auricularia auricula-judae* Quel of genetic diabetic KK-AY mice. *Biosci. Biotechnol. Biochem.* 1998; 62:1898-1903.
 125. Zhang M, Xiao GN, Salokhe VM. Preservation of strawberries by modified atmosphere packages with other treatments. *Packaging Technol. Sci.* 2006; 19:183-191.
 126. Zhuang C, Mizuno T, Shimada A, Ito H, Suzuki C, Mayuzumi Y, et al. Antitumor protein containing polysaccharides from a Chinese mushroom Fengweiguor Houbitake. *Pleurotus sajor-caju* (Fr), 1993.
 127. Goyal R, Grewal R, Goyal RK. Vitamin and mineral content of *Agaricus bisporus* (white button) and *Pleurotus sajor-caju* (dhingri) mushrooms. *Int. J. Food Sci. Nutr.* 2020;5:100-2.